

CHAPTER 8 (Odd)

1. $V_{ab} = E + IR = 10 \text{ V} + (6 \text{ A})(3 \Omega) = 28 \text{ V}$
3. a. $I_1 = \frac{E}{R_1} = \frac{24 \text{ V}}{2 \Omega} = 12 \text{ A}$, $I_{R_2} = \frac{E}{R_2 + R_3} = \frac{24 \text{ V}}{6 \Omega + 2 \Omega} = \frac{24 \text{ V}}{8 \Omega} = 3 \text{ A}$
 KCL: $I + I_s - I_1 - I_{R_2} = 0$
 $I_s = I_1 + I_{R_2} - I = 12 \text{ A} + 3 \text{ A} - 4 \text{ A} = 11 \text{ A}$
- b. $V_s = E = 24 \text{ V}$
 VDR: $V_3 = \frac{R_3 E}{R_2 + R_3} = \frac{2 \Omega (24 \text{ V})}{6 \Omega + 2 \Omega} = \frac{48 \text{ V}}{8} = 6 \text{ V}$
5. a. $I = \frac{E}{R_s} = \frac{18 \text{ V}}{6 \Omega} = 3 \text{ A}$, $R_p = R_s = 6 \Omega$
- b. $I = \frac{E}{R_s} = \frac{9 \text{ V}}{2.2 \text{ k}\Omega} = 4.091 \text{ mA}$, $R_p = R_s = 2.2 \text{ k}\Omega$
7. a. CDR: $I_L = \frac{R_s(I)}{R_s + R_L} = \frac{4 \Omega (12 \text{ A})}{4 \Omega + 2 \Omega} = 8 \text{ A}$
- b. $E_s = IR = (12 \text{ A})(4 \Omega) = 48 \text{ V}$
 $R_s = 4 \Omega$
 $I = \frac{E_s}{R_s + R_L} = \frac{48 \text{ V}}{4 \Omega + 2 \Omega} = 8 \text{ A}$
9. $I_T \uparrow = 7 \text{ A} - 3 \text{ A} = 4 \text{ A}$
 CDR: $I_1 = \frac{R_2(I_T)}{R_1 + R_2} = \frac{6 \Omega (4 \text{ A})}{4 \Omega + 6 \Omega} = 2.4 \text{ A}$
 $V_2 = I_T(R_1 \parallel R_2) = 4 \text{ A}(2.4 \Omega) = 9.6 \text{ V}$
11. a. $I = \frac{E}{R_2} = \frac{12 \text{ V}}{2.2 \text{ k}\Omega} = 5.4545 \text{ mA}$, $R_p = 2.2 \text{ k}\Omega$
- b. $I_T \uparrow = 8 \text{ mA} + 5.4545 \text{ mA} - 3 \text{ mA} = 10.4545 \text{ mA}$
 $R' = 6.8 \text{ k}\Omega \parallel 2.2 \text{ k}\Omega = 1.662 \text{ k}\Omega$
 $V_1 = I_T R' = (10.4545 \text{ mA})(1.662 \text{ k}\Omega)$
 $= 17.375 \text{ V}$
- c. $V_1 = V_2 + 12 \text{ V} \Rightarrow V_2 = V_1 - 12 \text{ V} = 17.375 \text{ V} - 12 \text{ V}$
 $= 5.375 \text{ V}$
- d. $I_2 = \frac{V_2}{R_2} = \frac{5.375 \text{ V}}{2.2 \text{ k}\Omega} = 2.443 \text{ mA}$

$$\begin{array}{l}
 13. \quad \text{(I): } \begin{array}{c} \overrightarrow{I_1} \downarrow I_3 \leftarrow I_2 \end{array} \quad \begin{array}{l} 10 - I_1 5.6 \text{ k}\Omega - I_3 2.2 \text{ k}\Omega + 20 = 0 \\ -20 + I_3 2.2 \text{ k}\Omega + I_2 3.3 \text{ k}\Omega - 30 = 0 \\ I_1 + I_2 = I_3 \end{array} \\
 \hline
 \end{array}$$

$$I_1 = I_{R_1} = 1.445 \text{ mA}, I_2 = I_{R_2} = 8.513 \text{ mA}, I_3 = I_{R_3} = 9.958 \text{ mA}$$

$$\begin{array}{l}
 \text{(II): } \begin{array}{c} \overrightarrow{I_1} \\ \leftarrow I_3 \\ \leftarrow I_2 \end{array} \quad \begin{array}{l} -1.2 \text{ k}\Omega I_1 + 9 - 8.2 \text{ k}\Omega I_3 = 0 \\ -10.2 \text{ k}\Omega I_2 + 8.2 \text{ k}\Omega I_3 + 6 = 0 \\ I_2 + I_3 = I_1 \end{array} \\
 \hline
 \end{array}$$

$$I_1 = 2.0316 \text{ mA}, I_2 = 1.2316 \text{ mA}, I_3 = 0.8 \text{ mA}$$

$$I_{R_1} = I_1 = 2.0316 \text{ mA}$$

$$I_{R_2} = I_3 = 0.8 \text{ mA}$$

$$I_{R_3} = I_{R_4} = I_2 = 1.2316 \text{ mA}$$

$$\begin{array}{l}
 15. \quad I_1 = I_{R_1} \text{ (CW)}, I_2 = I_{R_2} \text{ (down)}, I_3 = I_{R_3} \text{ (right)}, I_4 = I_{R_4} \text{ (down)} \\
 I_5 = I_{R_5} \text{ (CW)}
 \end{array}$$

$$\begin{array}{l}
 \text{a. } \begin{array}{l} E_1 - I_1 R_1 - I_2 R_2 = 0 \\ I_2 R_2 - I_3 R_3 - I_4 R_4 = 0 \\ I_4 R_4 - I_5 R_5 - E_2 = 0 \\ I_1 = I_2 + I_3 \\ I_3 = I_4 + I_5 \end{array} \\
 \hline
 \end{array}$$

$$\begin{array}{l}
 \text{b. } \begin{array}{l} E_1 - I_2(R_1 + R_2) - I_3 R_1 = 0 \\ I_2 R_2 - I_3(R_3 + R_4) + I_5 R_4 = 0 \\ I_3 R_4 - I_5(R_4 + R_5) - E_2 = 0 \end{array} \\
 \hline
 \end{array}$$

$$\begin{array}{l}
 \text{c. } \begin{array}{rcl} I_2(R_1 + R_2) + I_3 R_1 & + 0 & = E_1 \\ I_2 R_2 & - I_3(R_3 + R_4) + I_5 R_4 & = 0 \\ 0 & + I_3 R_4 & - I_5(R_4 + R_5) = E_2 \end{array} \\
 \hline
 \begin{array}{l} 3I_2 + 2I_3 + 0 = 10 \\ 1I_2 - 9I_3 + 5I_5 = 0 \\ 0 + 5I_3 - 8I_5 = 6 \end{array} \\
 \hline
 \end{array}$$

$$\text{d. } I_3 = I_{R_3} = -63.694 \text{ mA}$$

$$\begin{array}{l}
 17. \quad \text{a. } \begin{array}{c} \overrightarrow{I_1} \downarrow \overrightarrow{I_2} \end{array} \quad \begin{array}{l} 4 - 4I_1 - 8(I_1 - I_2) = 0 \\ -8(I_2 - I_1) - 2I_2 - 6 = 0 \end{array} \\
 \hline
 \end{array}$$

$$I_1 = -\frac{1}{7} \text{ A}, I_2 = -\frac{5}{7} \text{ A}$$

$$I_{R_1} = I_1 = -\frac{1}{7} \text{ A}$$

$$I_{R_2} = I_2 = -\frac{5}{7} \text{ A}$$

$$I_{R_3} = I_1 - I_2 = \left[-\frac{1}{7} \text{ A} \right] - \left[-\frac{5}{7} \text{ A} \right] = \frac{4}{7} \text{ A} \quad (\text{dir. of } I_1)$$

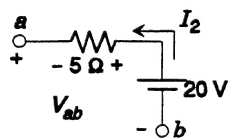
$$\begin{array}{rcl}
 \text{b.} & \begin{array}{c} \overbrace{I_1 \downarrow I_2 \downarrow} \\ -10 - 4I_1 - 3(I_1 - I_2) - 12 = 0 \\ 12 - 3(I_2 - I_1) - 12I_2 = 0 \end{array} & \\
 & \hline
 & I_1 = -3.0625 \text{ A}, I_2 = 0.1875 \text{ A}
 \end{array}$$

$$I_{R_1} = I_1 = -3.0625 \text{ A}$$

$$I_{R_3} = I_2 = 0.1875 \text{ A}$$

$$I_{R_2} = I_1 - I_2 = (-3.0625 \text{ A}) - (0.1875 \text{ A}) = -3.25 \text{ A}$$

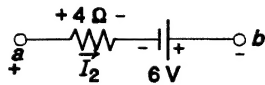
$$\begin{array}{rcl}
 19. \quad \text{(I):} & \begin{array}{c} \overbrace{I_1 \downarrow I_2 \downarrow} \\ -25 - 2I_1 - 3(I_1 - I_2) + 60 = 0 \\ -60 - 3(I_2 - I_1) + 6 - 5I_2 - 20 = 0 \end{array} & \\
 & \hline
 & I_1 = 1.8701 \text{ A}, I_2 = -8.5484 \text{ A}
 \end{array}$$



$$\begin{aligned}
 V_{ab} &= 20 - I_2 5 = 20 - (8.5484)(5) = 20 \text{ V} - 42.74 \text{ V} \\
 &= -22.74 \text{ V}
 \end{aligned}$$

(II): Source conversion: $E = 9 \text{ V}$, $R = 3 \Omega$

$$\begin{array}{rcl}
 & \begin{array}{c} \overbrace{I_2 \downarrow I_3 \downarrow} \\ 9 - 3I_2 - 4I_2 + 6 - 6(I_2 - I_3) = 0 \\ -6(I_3 - I_2) - 8I_3 - 4 = 0 \end{array} & \\
 & \hline
 & I_2 = 1.274 \text{ A}, I_3 = 0.26 \text{ A}
 \end{array}$$



$$\begin{aligned}
 V_{ab} &= I_2 4 - 6 = (1.274 \text{ A})(4 \Omega) - 6 \text{ V} \\
 &= 5.096 \text{ V} - 6 \text{ V} \\
 &= -0.904 \text{ V}
 \end{aligned}$$

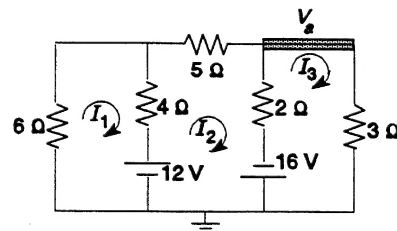
$$\begin{array}{rcl}
 21. \quad \text{a.} & \begin{array}{c} \overbrace{I_1 \downarrow I_2 \downarrow} \\ -1I_1 - 4 - 5I_1 + 6 - 1(I_1 - I_2) = 0 \\ -1(I_2 - I_1) - 6 - 3I_2 - 15 - 10I_2 = 0 \end{array} & \\
 & \hline
 & I_1 = I_{5\Omega} = 72.16 \text{ mA} \\
 & V_a = -4 - (72.16 \text{ mA})(6 \Omega) \\
 & \quad = -4 - 0.433 \text{ V} \\
 & \quad = -4.433 \text{ V}
 \end{array}$$

b. Network redrawn:

$$\begin{array}{rcl}
 -6I_1 - 4(I_1 - I_2) - 12 = 0 \\
 12 - 4(I_2 - I_1) - 5I_2 - 2(I_2 - I_3) + 16 = 0 \\
 -16 - 2(I_3 - I_2) - 3I_3 = 0
 \end{array}$$

$$I_2 = I_{5\Omega} = 1.953 \text{ A}$$

$$\begin{aligned}
 V_a &= (I_3)(3 \Omega) \\
 &= (-2.419 \text{ mA})(3 \Omega) \\
 &= -7.257 \text{ V}
 \end{aligned}$$



23. a. $\begin{matrix} I_1 \searrow & I_2 \searrow \\ I_4 \searrow & I_3 \searrow \end{matrix}$

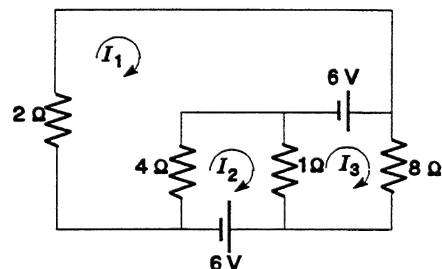
$$\begin{aligned} -6.8 \text{ k}\Omega I_1 - 4.7 \text{ k}\Omega(I_1 - I_2) + 6 - 2.2 \text{ k}\Omega(I_1 - I_4) &= 0 \\ -6 - 4.7 \text{ k}\Omega(I_2 - I_1) - 2.7 \text{ k}\Omega I_2 - 8.2 \text{ k}\Omega(I_2 - I_3) &= 0 \\ -1.1 \text{ k}\Omega I_3 - 22 \text{ k}\Omega(I_3 - I_4) - 8.2 \text{ k}\Omega(I_3 - I_2) - 9 &= 0 \\ 5 - 1.2 \text{ k}\Omega I_4 - 2.2 \text{ k}\Omega(I_4 - I_1) - 22 \text{ k}\Omega(I_4 - I_3) &= 0 \end{aligned}$$

$$I_1 = 0.0321 \text{ mA}, I_2 = -0.8838 \text{ mA}, I_3 = -0.968 \text{ mA}, I_4 = -0.639 \text{ mA}$$

b. Network redrawn:

$$\begin{aligned} -2I_1 - 6 - 4I_1 + 4I_2 &= 0 \\ -4I_2 + 4I_1 - 1I_2 + 1I_3 - 6 &= 0 \\ -1I_3 + 1I_2 + 6 - 8I_3 &= 0 \end{aligned}$$

$$I_1 = -3.8 \text{ A}, I_2 = -4.2 \text{ A}, I_3 = 0.2 \text{ A},$$



25. a. $\begin{matrix} I_1 \searrow & I_2 \searrow \end{matrix}$

$$\begin{aligned} (4 + 8)I_1 - 8I_2 &= 4 \\ (8 + 2)I_2 - 8I_1 &= -6 \end{aligned}$$

$$I_1 = -\frac{1}{7} \text{ A}, I_2 = -\frac{5}{7} \text{ A}$$

b. $\begin{matrix} I_1 \searrow & I_2 \searrow \end{matrix}$

$$\begin{aligned} (4 + 3)I_1 - 3I_2 &= -10 - 12 \\ (3 + 12)I_2 - 3I_1 &= 12 \end{aligned}$$

$$I_1 = -3.0625 \text{ A}, I_2 = 0.1875 \text{ A}$$

27. (I): a. $\begin{matrix} I_1 \searrow & I_2 \searrow \end{matrix}$

$$\begin{aligned} (2 + 3)I_1 - 3I_2 &= -25 + 60 \\ (3 + 5)I_2 - 3I_1 &= -60 + 6 - 20 \end{aligned}$$

b. $I_1 = 1.871 \text{ A}, I_2 = -8.548 \text{ A}$

c. $I_{R_1} = I_1 = 1.871 \text{ A}, I_{R_2} = I_2 = -8.548 \text{ A}$
 $I_{R_3} = I_1 - I_2 = 1.871 \text{ A} - (-8.548 \text{ A}) = 10.419 \text{ A}$ (direction of I_1)

(II): a. $\begin{matrix} I_2 \searrow & I_3 \searrow \end{matrix}$

$$\begin{aligned} (3 + 4 + 6)I_2 - 6I_3 &= 9 + 6 \\ (6 + 8)I_3 - 6I_2 &= -4 \end{aligned}$$

b. $I_2 = 1.274 \text{ A}, I_3 = 0.26 \text{ A}$

c. $I_{R_2} = I_2 = 1.274 \text{ A}, I_{R_3} = I_3 = 0.26 \text{ A}$
 $I_{R_4} = I_2 - I_3 = 1.274 \text{ A} - 0.26 \text{ A} = 1.014 \text{ A}$
 $I_{R_1} = 3 \text{ A} - I_2 = 3 \text{ A} - 1.274 \text{ A} = 1.726 \text{ A}$

29. From Sol. 21(b)

$$I_1 \downarrow I_2 \downarrow I_3 \downarrow$$

$$\begin{aligned} I_1(6 + 4) - 4I_2 &= -12 \\ I_2(4 + 5 + 2) - 4I_1 - 2I_3 &= 12 + 16 \\ I_3(2 + 3) - 2I_2 &= -16 \end{aligned}$$

$$I_{5\Omega} = I_2 = \mathbf{1.953 \text{ A}}$$

$$I_3 = -2.4186 \text{ A}, \therefore V_a = (I_3)(3 \Omega) = (-2.4186 \text{ A})(3 \Omega) = \mathbf{-7.26 \text{ V}}$$

31. a.

$$I_1 \downarrow I_2 \downarrow I_4 \downarrow I_3 \downarrow$$

$$\begin{aligned} I_1(6.8 \text{ k}\Omega + 4.7 \text{ k}\Omega + 2.2 \text{ k}\Omega) - 4.7 \text{ k}\Omega I_2 - 2.2 \text{ k}\Omega I_4 &= 6 \\ I_2(2.7 \text{ k}\Omega + 8.2 \text{ k}\Omega + 4.7 \text{ k}\Omega) - 4.7 \text{ k}\Omega I_1 - 8.2 \text{ k}\Omega I_3 &= -6 \\ I_3(8.2 \text{ k}\Omega + 1.1 \text{ k}\Omega + 22 \text{ k}\Omega) - 22 \text{ k}\Omega I_4 - 8.2 \text{ k}\Omega I_2 &= -9 \\ I_4(2.2 \text{ k}\Omega + 22 \text{ k}\Omega + 1.2 \text{ k}\Omega) - 2.2 \text{ k}\Omega I_1 - 22 \text{ k}\Omega I_3 &= 5 \end{aligned}$$

$$I_1 = \mathbf{0.0321 \text{ mA}}, I_2 = \mathbf{-0.8838 \text{ mA}}, I_3 = \mathbf{-0.968 \text{ mA}}, I_4 = \mathbf{-0.639 \text{ mA}}$$

b. From Sol. 23(b):

$$\begin{aligned} I_1(2 + 4) - 4I_2 &= -6 \\ I_2(4 + 1) - 4I_1 - 1I_3 &= -6 \\ I_3(1 + 8) - 1I_2 &= 6 \end{aligned}$$

$$I_1 = \mathbf{3.8 \text{ A}}, I_2 = \mathbf{-4.2 \text{ A}}, I_3 = \mathbf{0.2 \text{ A}}$$

33. (I): $\circ V_1 \quad \circ V_2$

$$V_1 \left[\frac{1}{3} + \frac{1}{6} + \frac{1}{4} \right] - \frac{1}{4} V_2 = -5 - 3$$

$$V_2 \left[\frac{1}{8} + \frac{1}{4} \right] - \frac{1}{4} V_1 = 3 - 4$$

$$V_1 = \mathbf{-14.86 \text{ V}}, V_2 = \mathbf{-12.57 \text{ V}}$$

$$V_{R_1} = V_{R_4} = \mathbf{-14.86 \text{ V}}$$

$$V_{R_2} = \mathbf{-12.57 \text{ V}}$$

$$^+V_{R_3}^- = 12 \text{ V} + 12.57 \text{ V} - 14.86 \text{ V} = \mathbf{9.71 \text{ V}}$$

(II): $\circ V_1 \quad \circ V_2$

$$V_1 \left[\frac{1}{5} + \frac{1}{3} + \frac{1}{2} \right] - \frac{1}{3} V_2 - \frac{1}{2} V_2 = -6$$

$$V_2 \left[\frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{8} \right] - \frac{1}{3} V_1 - \frac{1}{2} V_1 = 7$$

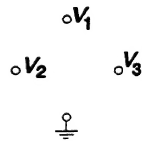
$$V_1 = \mathbf{-2.556 \text{ V}}, V_2 = \mathbf{4.03 \text{ V}}$$

$$V_{R_1} = \mathbf{-2.556 \text{ V}}$$

$$V_{R_2} = V_{R_5} = \mathbf{4.03 \text{ V}}$$

$$V_{R_4} = V_{R_3} = 4.03 \text{ V} + 2.556 \text{ V} = \mathbf{6.586 \text{ V}}$$

35. (I):



$$V_1 \left[\frac{1}{3} + \frac{1}{6} + \frac{1}{6} \right] - \frac{1}{6} V_2 - \frac{1}{6} V_3 = 5$$

$$V_2 \left[\frac{1}{6} + \frac{1}{4} + \frac{1}{5} \right] - \frac{1}{6} V_1 - \frac{1}{5} V_3 = -3$$

$$V_3 \left[\frac{1}{6} + \frac{1}{5} + \frac{1}{7} \right] - \frac{1}{5} V_2 - \frac{1}{6} V_1 = 0$$

$$V_1 = 7.238 \text{ V}, V_2 = -2.453 \text{ V}, V_3 = 1.405 \text{ V}$$

(II): Source conversion: $I = 4 \text{ A}$, $R = 4 \Omega$



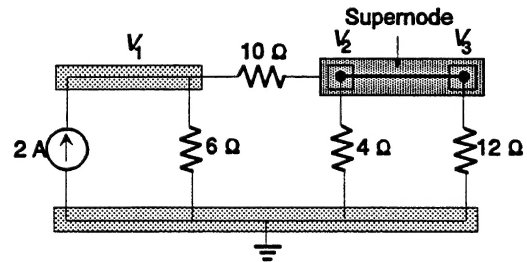
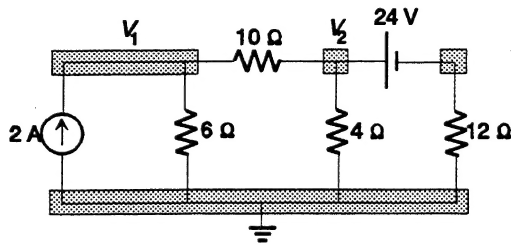
$$V_1 \left[\frac{1}{9} + \frac{1}{20} + \frac{1}{20} \right] - \frac{1}{20} V_2 - \frac{1}{20} V_3 = -2$$

$$V_2 \left[\frac{1}{20} + \frac{1}{20} + \frac{1}{18} \right] - \frac{1}{20} V_1 - \frac{1}{20} V_3 = 0$$

$$V_3 \left[\frac{1}{20} + \frac{1}{20} + \frac{1}{4} \right] - \frac{1}{20} V_2 - \frac{1}{20} V_1 = 4$$

$$V_1 = -6.642 \text{ V}, V_2 = 1.293 \text{ V}, V_3 = 10.664 \text{ V}$$

37. a.



$$\sum I_i = \sum I_o$$

Node V_1 :

$$2 \text{ A} = \frac{V_1}{6 \Omega} + \frac{V_1 - V_2}{10 \Omega}$$

Supernode V_2, V_3 :

$$0 = \frac{V_2 - V_1}{10 \Omega} + \frac{V_2}{4 \Omega} + \frac{V_3}{12 \Omega}$$

Independent source:

$$V_2 - V_3 = 24 \text{ V or } V_3 = V_2 - 24 \text{ V}$$

2 eq. 2 unknowns:

$$\frac{V_1}{6 \Omega} + \frac{V_1 - V_2}{10 \Omega} = 2 \text{ A}$$

$$\frac{V_2 - V_1}{10 \Omega} + \frac{V_2}{4 \Omega} + \frac{V_2 - 24 \text{ V}}{12 \Omega} = 0$$

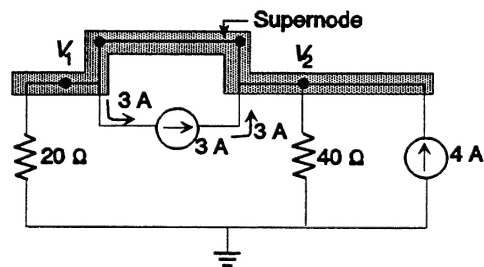
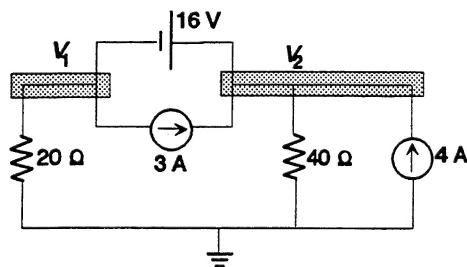
$$0.267 V_1 - 0.1 V_2 = 2$$

$$+0.1 V_1 - 0.433 V_2 = -2$$

$$V_1 = 10.083 \text{ V}, V_2 = 6.944 \text{ V}$$

$$V_3 = V_2 - 24 \text{ V} = -17.056 \text{ V}$$

b.



$$\Sigma I_i = \Sigma I_o$$

Supernode:

$$3 \text{ A} + 4 \text{ A} = 3 \text{ A} + \frac{V_1}{20 \Omega} + \frac{V_2}{40 \Omega}$$

$$2 \text{ eq. } 2 \text{ unk. } \begin{cases} 4 \text{ A} = \frac{V_1}{20 \Omega} + \frac{V_2}{40 \Omega} \\ V_2 - V_1 = 16 \text{ V} \end{cases}$$

$$\text{Subst. } V_2 = 16 \text{ V} + V_1$$

$$4 \text{ A} = \frac{V_1}{20 \Omega} + \frac{(16 \text{ V} + V_1)}{40 \Omega}$$

$$\text{and } V_1 = 48 \text{ V}$$

$$V_2 = 16 \text{ V} + V_1 = 64 \text{ V}$$

39. (I): a. Note the solution to problem 33(I).

b. $V_1 = -14.86 \text{ V}$, $V_2 = -12.57 \text{ V}$

c. $V_{R_1} = V_{R_4} = V_1 = -14.86 \text{ V}$, $V_{R_2} = V_2 = -12.57 \text{ V}$

$+ V_{R_3} -$

$V_{R_3} = V_1 - V_2 + 12 \text{ V} = (-14.86 \text{ V}) - (-12.57 \text{ V}) + 12 \text{ V} = 9.71 \text{ V}$

(II): a. Note the solution to problem 33(II).

b. $V_1 = -2.556 \text{ V}$, $V_2 = 4.03 \text{ V}$

c. $V_{R_1} = V_1 = -2.556 \text{ V}$, $V_{R_2} = V_{R_5} = V_2 = 4.03 \text{ V}$

$V_{R_3} = V_{R_4} = V_2^{(+)} - V_1^{(-)} = 6.586 \text{ V}$

41. a. Note the solution to problem 36(I).

$V_1 = -5.311 \text{ V}$, $V_2 = -0.6219 \text{ V}$, $V_3 = 3.751 \text{ V}$

$V_{5A} = V_1 = -5.311 \text{ V}$

b. Note the solution to problem 36(II).

$V_1 = -6.917 \text{ V}$, $V_2 = 12 \text{ V}$, $V_3 = 2.3 \text{ V}$

$V_{2A} = V_2^{(+)} - V_3^{(-)} = 9.7 \text{ V}$, $V_{5A} = V_2^{(+)} - V_1^{(-)} = 18.917 \text{ V}$

43. Source conversion: $I = 1 \text{ A}$, $R = 6 \Omega$

$$\begin{array}{ccc} \circ V_1 & & \\ \circ V_3 & & \circ V_2 \\ \text{---} & & \end{array} \quad \begin{aligned} \left[\frac{1}{6} + \frac{1}{5} + \frac{1}{5} \right] V_1 - \frac{1}{5} V_2 - \frac{1}{5} V_3 &= 1 \\ \left[\frac{1}{5} + \frac{1}{5} + \frac{1}{20} \right] V_2 - \frac{1}{5} V_1 - \frac{1}{5} V_3 &= 0 \\ \left[\frac{1}{5} + \frac{1}{5} + \frac{1}{10} \right] V_3 - \frac{1}{5} V_1 - \frac{1}{5} V_2 &= 0 \end{aligned}$$

$$V_{R_5} = 0.1967 \text{ V, no}$$

45. Source conversion: $I = 12 \text{ A}$, $R = 2 \text{ k}\Omega$

$$\begin{array}{ccc} \circ V_1 & & \\ \circ V_3 & & \circ V_2 \\ \text{---} & & \end{array} \quad \begin{aligned} \left[\frac{1}{2 \text{ k}\Omega} + \frac{1}{33 \text{ k}\Omega} + \frac{1}{56 \text{ k}\Omega} \right] V_1 - \frac{1}{56 \text{ k}\Omega} V_2 - \frac{1}{33 \text{ k}\Omega} V_3 &= 12 \\ \left[\frac{1}{56 \text{ k}\Omega} + \frac{1}{36 \text{ k}\Omega} + \frac{1}{5.6 \text{ k}\Omega} \right] V_2 - \frac{1}{56 \text{ k}\Omega} V_1 - \frac{1}{36 \text{ k}\Omega} V_3 &= 0 \\ \left[\frac{1}{33 \text{ k}\Omega} + \frac{1}{3.3 \text{ k}\Omega} + \frac{1}{36 \text{ k}\Omega} \right] V_3 - \frac{1}{33 \text{ k}\Omega} V_1 - \frac{1}{36 \text{ k}\Omega} V_2 &= 0 \end{aligned}$$

$$I_{R_5} = 0 \text{ A, yes}$$

47. a.

$$\begin{array}{c} I_1 \downarrow \\ I_2 \downarrow \\ I_3 \downarrow \end{array}$$

$$\begin{aligned} (1 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega) I_1 - 2 \text{ k}\Omega I_2 - 2 \text{ k}\Omega I_3 &= 10 \\ (2 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega) I_2 - 2 \text{ k}\Omega I_1 - 2 \text{ k}\Omega I_3 &= 0 \\ (2 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega) I_3 - 2 \text{ k}\Omega I_1 - 2 \text{ k}\Omega I_2 &= 0 \end{aligned}$$

$$I_1 = I_{10V} = 3.33 \text{ mA}$$

Source conversion: $I = 10 \text{ V}/1 \text{ k}\Omega = 10 \text{ mA}$, $R = 1 \text{ k}\Omega$

$$\begin{array}{ccc} \circ V_1 & & \\ \circ V_3 & & \circ V_2 \\ \text{---} & & \end{array} \quad \begin{aligned} V_1 \left[\frac{1}{1 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} \right] - \frac{1}{2 \text{ k}\Omega} V_2 - \frac{1}{2 \text{ k}\Omega} V_3 &= 10 \text{ mA} \\ V_2 \left[\frac{1}{2 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} \right] - \frac{1}{2 \text{ k}\Omega} V_1 - \frac{1}{2 \text{ k}\Omega} V_3 &= 0 \\ V_3 \left[\frac{1}{2 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} + \frac{1}{2 \text{ k}\Omega} \right] - \frac{1}{2 \text{ k}\Omega} V_2 - \frac{1}{2 \text{ k}\Omega} V_1 &= 0 \end{aligned}$$

$$V_1 = 6.67 \text{ V} = E - IR_s = 10 \text{ V} - I(1 \text{ k}\Omega)$$

$$I = \frac{10 - 6.67 \text{ V}}{1 \text{ k}\Omega} = 3.33 \text{ mA}$$

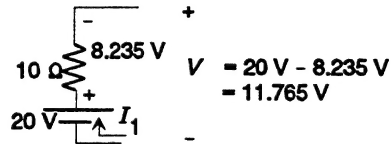
- b.

$$\begin{array}{c} I_1 \downarrow \\ I_2 \downarrow \\ I_3 \downarrow \end{array}$$

Source conversion: $E = 20 \text{ V}$, $R = 10 \Omega$

$$\begin{aligned} (10 + 10 + 20) I_1 - 10 I_2 - 20 I_3 &= 20 \\ (10 + 20 + 20) I_2 - 10 I_1 - 20 I_3 &= 0 \\ (20 + 20 + 10) I_3 - 20 I_1 - 20 I_2 &= 0 \end{aligned}$$

$$I_1 = I_{20V} = 0.8235 \text{ A}$$

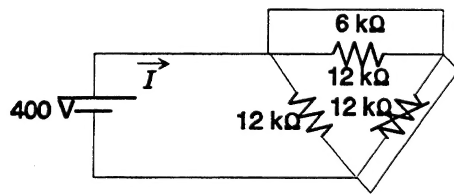


$$I_s = \frac{V}{R_s} = \frac{11.765\text{ V}}{10\ \Omega} = 1.177\text{ A}$$

$$\begin{array}{l} \circ V_1 \\ \circ V_3 \quad \circ V_2 \\ \text{---} \end{array} \quad \begin{array}{l} V_1 \left[\frac{1}{10} + \frac{1}{10} + \frac{1}{20} \right] - \left[\frac{1}{20} \right] V_2 - \left[\frac{1}{10} \right] V_3 = 2 \\ V_2 \left[\frac{1}{20} + \frac{1}{20} + \frac{1}{10} \right] - \left[\frac{1}{20} \right] V_1 - \left[\frac{1}{20} \right] V_3 = 0 \\ V_3 \left[\frac{1}{10} + \frac{1}{20} + \frac{1}{20} \right] - \left[\frac{1}{10} \right] V_1 - \left[\frac{1}{20} \right] V_2 = 0 \end{array}$$

$$I_{R_s} = \frac{V_1}{R_s} = 1.177\text{ A}$$

49. a.

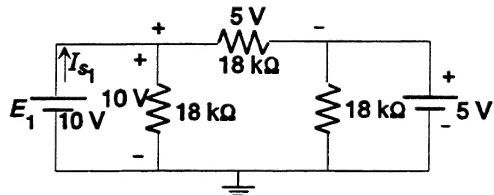


(Y-Δ conversion)

$$I = \frac{400\text{ V}}{12\text{ k}\Omega \parallel 12\text{ k}\Omega \parallel 6\text{ k}\Omega} = \frac{400\text{ V}}{3\text{ k}\Omega} = 133.33\text{ mA}$$

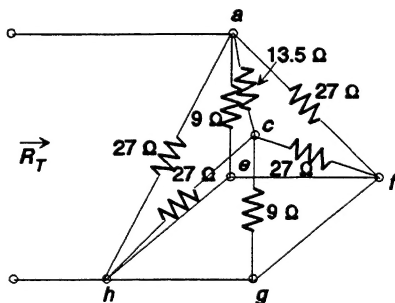
$$\begin{aligned} \text{b. } I &= \frac{42\text{ V}}{(18\ \Omega \parallel 18\ \Omega) \parallel [(18\ \Omega \parallel 18\ \Omega) + (18\ \Omega \parallel 18\ \Omega)]} = \frac{42\text{ V}}{9\ \Omega \parallel [9\ \Omega + 9\ \Omega]} \\ &= 7\text{ A (Y-}\Delta\text{ conversion)} \end{aligned}$$

51.



$$I_{s_1} = \frac{10\text{ V}}{18\text{ k}\Omega} + \frac{5\text{ V}}{18\text{ k}\Omega} = \frac{15\text{ V}}{18\text{ k}\Omega} = 0.833\text{ mA}$$

53.




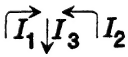


$$c - g: 27\ \Omega \parallel 9\ \Omega \parallel 27\ \Omega = 5.4\ \Omega$$

$$a - h: 27\ \Omega \parallel 9\ \Omega \parallel 27\ \Omega = 5.4\ \Omega$$

$$\begin{aligned} R_T &= 5.4\ \Omega \parallel (13.5\ \Omega + 5.4\ \Omega) \\ &= 5.4\ \Omega \parallel 18.9\ \Omega \\ &= 4.2\ \Omega \end{aligned}$$

CHAPTER 8 (Even)

2. a. CDR: $I_{6\Omega} = \frac{10 \text{ k}\Omega(4 \text{ A})}{10 \text{ k}\Omega + 8 \Omega} = 3.997 \text{ A}$
 $V_{6\Omega} = I_{6\Omega}(6 \Omega) = (3.997 \text{ A})(6 \Omega) = 23.982 \text{ V}$
- b. $V_{6\Omega} = I_{6\Omega}(6 \Omega) = (4 \text{ A})(6 \Omega) = 24 \text{ V}$. Yes, a good approximation.
4. $V_1 = V_2 = V_s = IR_T = 0.6 \text{ A}[6 \Omega \parallel 24 \Omega \parallel 24 \Omega] = 0.6 \text{ A}[6 \Omega \parallel 12 \Omega] = 2.4 \text{ V}$
 $I_2 = \frac{V_2}{R_2} = \frac{2.4 \text{ V}}{24 \Omega} = 0.1 \text{ A}$
 $V_3 = \frac{R_3 V_s}{R_3 + R_4} = \frac{16\Omega(2.4 \text{ V})}{24 \Omega} = 1.6 \text{ V}$
6. a. $E = IR_s = (1.5 \text{ A})(3 \Omega) = 4.5 \text{ V}$, $R_s = 3 \Omega$
- b. $E = IR_s = (6 \text{ mA})(4.7 \text{ k}\Omega) = 28.2 \text{ V}$, $R_s = 4.7 \text{ k}\Omega$
8. a. $E = IR_2 = (2 \text{ A})(6.8 \Omega) = 13.6 \text{ V}$, $R = 6.8 \Omega$
- b.  $I_1 = (12 \text{ V} + 13.6 \text{ V})/(10 \Omega + 6.8 \Omega + 39 \Omega) = \frac{25.6 \text{ V}}{55.8 \Omega} = 458.78 \text{ mA}$
- c. $V_{ab} = I_1 R_3 = (458.78 \text{ mA})(39 \Omega) = 17.89 \text{ V}$

10. a. Conversions: $I_1 = E_1/R_1 = 9 \text{ V}/3 \Omega = 3 \text{ A}$, $R_1 = 3 \Omega$
 $I_2 = E_2/R_2 = 20 \text{ V}/2 \Omega = 10 \text{ A}$, $R_2 = 2 \Omega$
- b. $I_T \downarrow = 10 \text{ A} - 3 \text{ A} = 7 \text{ A}$, $R_T = 3 \Omega \parallel 6 \Omega \parallel 2 \Omega \parallel 12 \Omega$
 $= 2 \Omega \parallel 2 \Omega \parallel 12 \Omega$
 $= 1 \Omega \parallel 12 \Omega$
 $= 0.9231 \Omega$
 $V_{ab} = -I_T R_T = -(7 \text{ A})(0.9231 \Omega) = -6.462 \text{ V}$

- c. $I \uparrow = \frac{6.462 \text{ V}}{6 \Omega} = 1.077 \text{ A}$
12. a. 
$$\begin{aligned} 4 - 4I_1 - 8I_3 &= 0 \\ 6 - 2I_2 - 8I_3 &= 0 \\ I_1 + I_2 &= I_3 \end{aligned}$$

$$I_1 = -\frac{1}{7} \text{ A}, I_2 = \frac{5}{7} \text{ A}, I_3 = \frac{4}{7} \text{ A}$$
$$I_{R_1} = I_1 = -\frac{1}{7} \text{ A}, I_{R_2} = I_2 = \frac{5}{7} \text{ A}, I_{R_3} = I_3 = \frac{4}{7} \text{ A}$$

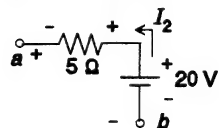
$$\begin{array}{lcl}
 \text{b.} & \begin{array}{c} \begin{array}{c} \overrightarrow{I_1} \uparrow \overrightarrow{I_3} \leftarrow \overrightarrow{I_2} \\ \hline \end{array} \end{array} & \begin{array}{l} 10 + 12 - 3I_3 - 4I_1 = 0 \\ 12 - 3I_3 - 12I_2 = 0 \\ I_1 + I_2 = I_3 \end{array} & \begin{array}{l} I_1 = 3.0625 \text{ A} \\ I_2 = 0.1875 \text{ A} \\ I_3 = 3.25 \text{ A} \end{array}
 \end{array}$$

$$I_{R_1} = I_1 = 3.0625 \text{ A}, I_{R_2} = I_2 = 3.25 \text{ A}$$

$$I_{R_3} = I_3 = 0.1875 \text{ A}$$

$$\begin{array}{lcl}
 14. \quad \text{(I):} & \begin{array}{c} \begin{array}{c} \overrightarrow{I_1} \downarrow \overrightarrow{I_3} \downarrow \overrightarrow{I_2} \\ \hline \end{array} \end{array} & \begin{array}{l} -25 - 2I_1 - 3I_3 + 60 = 0 \\ -60 + 3I_3 + 6 - 5I_2 - 20 = 0 \\ I_1 = I_2 + I_3 \end{array}
 \end{array}$$

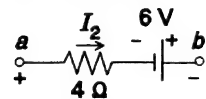
$$I_2 = -8.548 \text{ A}$$



$$\begin{aligned}
 V_{ab} &= 20 \text{ V} - I_2 5 \Omega \\
 &= 20 \text{ V} - (-8.548 \text{ A})(5 \Omega) \\
 &= -22.75 \text{ V}
 \end{aligned}$$

$$\text{(II): Source conversion: } E = IR_1 = (3 \text{ A})(3 \Omega) = 9 \text{ V}, R_1 = 3 \Omega$$

$$\begin{array}{lcl}
 & \begin{array}{c} \begin{array}{c} \overrightarrow{I_2} \downarrow \overrightarrow{I_4} \downarrow \overrightarrow{I_3} \\ \hline \end{array} \end{array} & \begin{array}{l} 9 + 6 - 3I_2 - 4I_2 - 6I_4 = 0 \\ + 6I_4 - 8I_3 - 4 = 0 \\ I_2 = I_3 + I_4 \\ I_2 = 1.274 \text{ A} \end{array}
 \end{array}$$



$$\begin{aligned}
 V_{ab} &= I_2 4 \Omega - 6 \text{ V} \\
 &= (1.274 \text{ A})4 \Omega - 6 \text{ V} \\
 &= -0.904 \text{ V}
 \end{aligned}$$

$$\begin{array}{lcl}
 16. \quad \text{a.} & \begin{array}{l} 20 \text{ V} - I_B(270 \text{ k}\Omega) - 0.7 \text{ V} - I_E(0.51 \text{ k}\Omega) = 0 \\ I_E(0.51 \text{ k}\Omega) + 8 \text{ V} + I_C(2.2 \text{ k}\Omega) - 20 \text{ V} = 0 \\ I_E = I_B + I_C \end{array} &
 \end{array}$$

$$I_B = 63.02 \mu\text{A}, I_C = 4.416 \text{ mA}, I_E = 4.479 \text{ mA}$$

$$\text{b. } V_B = 2.985 \text{ V}, V_E = 2.285 \text{ V}, V_C = 10.285 \text{ V}$$

$$\text{c. } \beta \cong 70.07$$

18. (I): $\overbrace{I_1 \downarrow I_2 \downarrow}$

$$\begin{aligned} 10 - I_1(5.6 \text{ k}\Omega) - 2.2 \text{ k}\Omega(I_1 - I_2) + 20 &= 0 \\ -20 - 2.2 \text{ k}\Omega(I_2 - I_1) - I_2 3.3 \text{ k}\Omega - 30 &= 0 \end{aligned}$$

$$\begin{aligned} I_1 &= 1.445 \text{ mA}, I_2 = 8.513 \text{ mA} \\ I_{R_1} &= I_1 = 1.445 \text{ mA}, I_{R_2} = I_2 = 8.513 \text{ mA} \\ I_{R_3} &= I_2 - I_1 = 7.068 \text{ mA} \text{ (direction of } I_2) \end{aligned}$$

(II): $\overbrace{I_1 \downarrow I_2 \downarrow}$

$$\begin{aligned} -I_1(1.2 \text{ k}\Omega) + 9 - 8.2 \text{ k}\Omega(I_1 - I_2) &= 0 \\ -I_2(1.1 \text{ k}\Omega) + 6 - I_2(9.1 \text{ k}\Omega) - 8.2 \text{ k}\Omega(I_2 - I_1) &= 0 \end{aligned}$$

$$\begin{aligned} I_1 &= 2.0337 \text{ mA}, I_2 = 1.2316 \text{ mA} \\ I_{R_1} &= I_1 = 2.0337 \text{ mA}, I_{R_3} = I_{R_4} = I_2 = 1.2316 \text{ mA} \\ I_{R_2} &= I_2 - I_1 = 2.0337 \text{ mA} - 1.2316 \text{ mA} = 0.8021 \text{ mA} \text{ (direction of } I_1) \end{aligned}$$

20. $I_1 \downarrow I_2 \downarrow I_3 \downarrow$

$$\begin{aligned} 10 - I_1 2 - 1(I_1 - I_2) &= 0 \\ -1(I_2 - I_1) - I_2 4 - 5(I_2 - I_3) &= 0 \\ -5(I_3 - I_2) - I_3 3 - 6 &= 0 \end{aligned}$$

$$\begin{aligned} 3I_1 - 1I_2 + 0 &= 10 \\ -1I_1 + 10I_2 - 5I_3 &= 0 \\ 0 - 5I_2 + 8I_3 &= -6 \end{aligned}$$

$$I_2 = I_{R_3} = -63.694 \text{ mA}$$

22. (I): $I_1 \downarrow I_2 \downarrow I_3 \downarrow$

$$\begin{aligned} I_1(2.2 \text{ k}\Omega + 9.1 \text{ k}\Omega) - 9.1 \text{ k}\Omega I_2 &= 18 \\ I_2(9.1 \text{ k}\Omega + 7.5 \text{ k}\Omega + 6.8 \text{ k}\Omega) - 9.1 \text{ k}\Omega I_1 - 6.8 \text{ k}\Omega I_3 &= -18 \\ I_3(6.8 \text{ k}\Omega + 3.3 \text{ k}\Omega) - I_2 6.8 \text{ k}\Omega &= -3 \end{aligned}$$

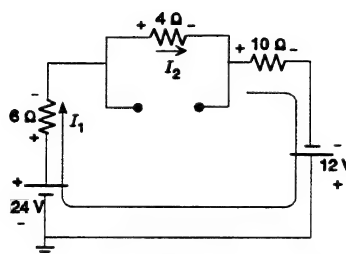
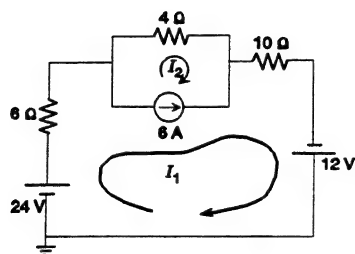
$$I_1 = 1.2059 \text{ mA}, I_2 = -0.4806 \text{ mA}, I_3 = -0.6206 \text{ mA}$$

(II): $\overbrace{I_1 \downarrow I_2 \downarrow I_3 \downarrow}$

$$\begin{aligned} 16 - 4I_1 - 3(I_1 - I_2) - 12 - 4(I_1 - I_3) &= 0 \\ 12 - 3(I_2 - I_1) - 10 I_2 - 15 - 4(I_2 - I_3) &= 0 \\ -16 - 4(I_3 - I_1) - 4(I_3 - I_2) - 7I_3 &= 0 \end{aligned}$$

$$I_1 = -0.2385 \text{ A}, I_2 = -0.5169 \text{ A}, I_3 = -1.278 \text{ A}$$

24. a.



$$24 \text{ V} - 6I_1 - 4I_2 - 10I_1 + 12 \text{ V} = 0$$

$$\text{and } 16I_1 + 4I_2 = 36$$

$$I_1 - I_2 = 6 \text{ A}$$

$$I_1 = I_2 + 6 \text{ A}$$

$$16[I_2 + 6 \text{ A}] + 4I_2 = 36$$

$$16I_2 + 96 + 4I_2 = 36$$

$$20I_2 = -60$$

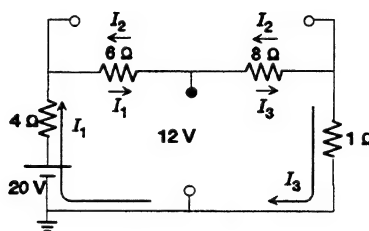
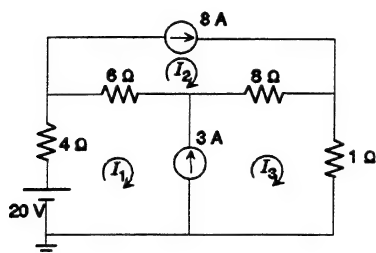
$$I_2 = -3 \text{ A}$$

$$I_1 = I_2 + 6 \text{ A} = -3 \text{ A} + 6 \text{ A} = 3 \text{ A}$$

$$I_{24\text{V}} = I_{6\Omega} = I_{10\Omega} = I_{12\text{V}} = 3 \text{ A (CW)}$$

$$I_{4\Omega} = 3 \text{ A (CCW)}$$

b.



$$20 \text{ V} - 4I_1 - 6(I_1 - I_2) - 8(I_3 - I_2) - 1I_3 = 0$$

$$10I_1 - 14I_2 + 9I_3 = 20$$

$$I_3 - I_1 = 3 \text{ A}$$

$$I_2 = 8 \text{ A}$$

$$10I_1 - 14(8 \text{ A}) + 9[I_1 + 3 \text{ A}] = 20$$

$$19I_1 = 105$$

$$I_1 = 5.526 \text{ A}$$

$$I_3 = I_1 + 3 \text{ A} = 5.526 \text{ A} + 3 \text{ A} = 8.526 \text{ A}$$

$$I_2 = 8$$

$$I_{20\text{V}} = I_{4\Omega} = 5.526 \text{ A (dir. of } I_1)$$

$$I_{6\Omega} = I_2 - I_1 = 2.474 \text{ A (dir. of } I_2)$$

$$I_{8\Omega} = I_3 - I_2 = 0.526 \text{ A (dir. of } I_3)$$

$$I_{1\Omega} = 8.526 \text{ A (dir. of } I_3)$$

26. (I): $\overrightarrow{I_1} \downarrow \overrightarrow{I_2} \downarrow$

a. $I_1(5.6 \text{ k}\Omega + 2.2 \text{ k}\Omega) - 2.2 \text{ k}\Omega (I_2) = 10 + 20$

$I_2(2.2 \text{ k}\Omega + 3.3 \text{ k}\Omega) - 2.2 \text{ k}\Omega (I_1) = -20 - 30$

b. $I_1 = 1.445 \text{ mA}, I_2 = -8.513 \text{ mA}$

$$\begin{aligned} \text{c. } I_{R_1} &= I_1 = 1.445 \text{ mA}, I_{R_2} = I_2 = -8.513 \text{ mA} \\ I_{R_3} &= I_1 + I_2 = 8.513 \text{ mA} + 1.445 \text{ mA} = 9.958 \text{ mA (direction of } I_1) \end{aligned}$$

$$\text{(II): } \begin{array}{l} I_1 \downarrow \\ I_2 \downarrow \end{array}$$

$$\begin{aligned} \text{a. } I_1(1.2 \text{ k}\Omega + 8.2 \text{ k}\Omega) - 8.2 \text{ k}\Omega I_2 &= 9 \\ I_2(8.2 \text{ k}\Omega + 1.1 \text{ k}\Omega + 9.1 \text{ k}\Omega) - 8.2 \text{ k}\Omega I_1 &= 6 \end{aligned}$$

$$\text{b. } I_1 = 2.0316 \text{ mA}, I_2 = 1.2316 \text{ mA}$$

$$\begin{aligned} \text{c. } I_{R_1} &= I_1 = 2.0316 \text{ mA}, I_{R_3} = I_{R_4} = I_2 = 1.2316 \text{ mA} \\ I_{R_2} &= I_1 - I_2 = 2.0316 \text{ mA} - 1.2316 \text{ mA} = 0.8 \text{ mA (direction of } I_1) \end{aligned}$$

$$\begin{aligned} 28. \quad & \begin{array}{l} I_1 \downarrow \\ I_2 \downarrow \\ I_3 \downarrow \end{array} \\ & I_1(2 + 1) - 1I_2 = 10 \\ & I_2(1 + 4 + 5) - 1I_1 - 5I_3 = 0 \\ & I_3(5 + 3) - 5I_2 = -6 \end{aligned}$$

$$I_2 = I_{R_3} = -63.694 \text{ mA (exact match with problem 15)}$$

$$\begin{aligned} 30. \quad \text{(I): } & \begin{array}{l} I_1 \downarrow \\ I_2 \downarrow \\ I_3 \downarrow \end{array} \\ & (2.2 \text{ k}\Omega + 9.1 \text{ k}\Omega)I_1 - 9.1 \text{ k}\Omega I_2 = 18 \\ & (9.1 \text{ k}\Omega + 7.5 \text{ k}\Omega + 6.8 \text{ k}\Omega)I_2 - 9.1 \text{ k}\Omega I_1 - 6.8 \text{ k}\Omega I_3 = -18 \\ & (6.8 \text{ k}\Omega + 3.3 \text{ k}\Omega)I_3 - 6.8 \text{ k}\Omega I_2 = -3 \end{aligned}$$

$$I_1 = 1.2059 \text{ mA}, I_2 = -0.4806 \text{ mA}, I_3 = -0.6206 \text{ mA}$$

$$\begin{aligned} \text{(II): } & \begin{array}{l} I_1 \downarrow \\ I_2 \downarrow \\ I_3 \downarrow \end{array} \quad \begin{aligned} (4 \Omega + 4 \Omega + 3 \Omega)I_1 - 3 \Omega I_2 - 4 \Omega I_3 &= 16 - 12 \\ (4 \Omega + 3 \Omega + 10 \Omega)I_2 - 3I_1 - 4 \Omega I_3 &= 12 - 15 \\ (4 \Omega + 4 \Omega + 7 \Omega)I_3 - 4I_1 - 4I_2 &= -16 \end{aligned} \end{aligned}$$

$$I_1 = -0.2385 \text{ A}, I_2 = -0.5169 \text{ A}, I_3 = -1.278 \text{ A}$$

$$\begin{aligned} 32. \quad \text{a. } & \begin{array}{l} \circ V_1 \quad \circ V_2 \\ V_1 \left[\frac{1}{2} + \frac{1}{5} + \frac{1}{2} \right] - \frac{1}{2} V_2 = 5 \\ V_2 \left[\frac{1}{2} + \frac{1}{4} \right] - \frac{1}{2} V_1 = 3 \end{array} \quad \begin{array}{l} V_1 = 8.077 \text{ V} \\ V_2 = 9.385 \text{ V} \end{array} \end{aligned}$$

Symmetry is present

b. $\begin{matrix} \circ V_1 & \circ V_2 \\ V_1 \left[\frac{1}{2} + \frac{1}{4} \right] - \frac{1}{4} V_2 = 4 - 2 & V_1 = 4.8 \text{ V} \\ & V_2 = 6.4 \text{ V} \\ V_2 \left[\frac{1}{4} + \frac{1}{20} + \frac{1}{5} \right] - \frac{1}{4} V_1 = 2 \end{matrix}$

Symmetry is present

34. (I): a. $\begin{matrix} \circ V_1 & \circ V_2 \\ V_1 \left[\frac{1}{2.2 \text{ k}\Omega} + \frac{1}{9.1 \text{ k}\Omega} + \frac{1}{7.5 \text{ k}\Omega} \right] - \frac{1}{7.5 \text{ k}\Omega} V_2 = -1.978 \text{ mA} \\ V_2 \left[\frac{1}{7.5 \text{ k}\Omega} + \frac{1}{6.8 \text{ k}\Omega} + \frac{1}{3.3 \text{ k}\Omega} \right] - \frac{1}{7.5 \text{ k}\Omega} V_1 = 0.909 \text{ mA} \end{matrix}$

b. $V_1 = -2.653 \text{ V}, V_2 = 0.952 \text{ V}$

c. $V_{R_3} = V_1 = -2.653 \text{ V}, V_{R_5} = V_2 = 0.952 \text{ V}, V_{R_4} = \overset{(+)}{V_2} - \overset{(-)}{V_1} = 3.605 \text{ V}$

$R_1 \begin{matrix} | \\ \text{---} \\ | \end{matrix} \overset{+}{V}_{R_1} = 18 \text{ V} - 2.653 \text{ V} = 15.347 \text{ V}$

$R_2 \begin{matrix} | \\ \text{---} \\ | \end{matrix} \overset{-}{V}_{R_2} = 3 \text{ V} - 0.952 \text{ V} = 2.048 \text{ V}$

(II): a. $\begin{matrix} \circ V_1 & \circ V_2 \\ \circ V_3 & \\ \text{---} & \end{matrix} \quad \begin{matrix} V_1 \left[\frac{1}{4} + \frac{1}{4} + \frac{1}{7} \right] - \frac{1}{4} V_2 - \frac{1}{4} V_3 = 4 \\ V_2 \left[\frac{1}{4} + \frac{1}{3} + \frac{1}{10} \right] - \frac{1}{4} V_1 - \frac{1}{3} V_3 = 4 + 1.5 \\ V_3 \left[\frac{1}{4} + \frac{1}{3} + \frac{1}{4} \right] - \frac{1}{4} V_1 - \frac{1}{3} V_2 = -4 - 4 \end{matrix}$

b. $V_1 = 8.877 \text{ V}, V_2 = 9.831 \text{ V}, V_3 = -3.005 \text{ V}$

c. $V_{R_6} = V_1 = 8.877 \text{ V}, V_{R_4} = V_3 = -3.005 \text{ V}, V_{R_5} = \overset{(+)}{V_2} - \overset{(-)}{V_1} = 0.954 \text{ V}$

$\begin{matrix} -V_{R_1} + \\ \text{---} \\ R_1 \end{matrix} V_{R_1} = 16 \text{ V} - V_1 + V_3 = 4.118 \text{ V}$

$\begin{matrix} -V_{R_2} + \\ \text{---} \\ R_2 \end{matrix} V_{R_2} = V_2 - V_3 - 12 \text{ V} = 0.836 \text{ V}$

$R_3 \begin{matrix} | \\ \text{---} \\ | \end{matrix} \overset{-}{V}_{R_3} = 15 \text{ V} - V_2 = 5.169 \text{ V}$

36. (I) $\begin{matrix} \circ V_1 & \circ V_2 & \circ V_3 \\ \left[\frac{1}{2} + \frac{1}{2} \right] V_1 - \frac{1}{2} V_2 + 0 = -5 \\ \left[\frac{1}{2} + \frac{1}{9} + \frac{1}{7} + \frac{1}{2} \right] V_2 - \frac{1}{2} V_1 - \frac{1}{2} V_3 = 0 \\ \left[\frac{1}{2} + \frac{1}{2} + \frac{1}{4} \right] V_3 - \frac{1}{2} V_2 = 5 \end{matrix}$

$V_1 = -5.311 \text{ V}, V_2 = -0.6219 \text{ V}, V_3 = 3.751 \text{ V}$

(II) $\begin{matrix} \circ V_1 & \circ V_2 \\ \circ V_3 & \text{---} \end{matrix}$

$$\begin{aligned} V_1 \left[\frac{1}{2} + \frac{1}{6} \right] - \frac{1}{6} V_3 &= -5 \\ V_2 \left[\frac{1}{4} \right] &= 5 - 2 \\ V_3 \left[\frac{1}{6} + \frac{1}{5} \right] - \frac{1}{6} V_1 &= 2 \end{aligned}$$

$V_1 = -6.917 \text{ V}, V_2 = 12 \text{ V}, V_3 = 2.3 \text{ V}$

38. a. $\begin{matrix} \circ V_1 & \circ V_2 \end{matrix}$

$$\begin{aligned} V_1 \left[\frac{1}{2} + \frac{1}{5} + \frac{1}{2} \right] - \frac{1}{2} V_2 &= 5 \\ V_2 \left[\frac{1}{2} + \frac{1}{4} \right] - \frac{1}{2} V_1 &= 3 \end{aligned}$$

$V_1 = 8.077 \text{ V}, V_2 = 9.385 \text{ V}$

Symmetry present

b. $\begin{matrix} \circ V_1 & \circ V_2 \end{matrix}$

$$\begin{aligned} V_1 \left[\frac{1}{2} + \frac{1}{4} \right] - \frac{1}{4} V_2 &= 4 - 2 \\ V_2 \left[\frac{1}{4} + \frac{1}{20} + \frac{1}{5} \right] - \frac{1}{4} V_1 &= 2 \end{aligned}$$

$V_1 = 4.8 \text{ V}, V_2 = 6.4 \text{ V}$

Symmetry present

40. (I): a. Source conversion: $I = 5 \text{ A}, R = 3 \Omega$

$$\begin{matrix} \circ V_1 \\ \circ V_2 & \circ V_3 \\ \text{---} \end{matrix}$$

$$\begin{aligned} V_1 \left[\frac{1}{3} + \frac{1}{6} + \frac{1}{6} \right] - \frac{1}{6} V_2 - \frac{1}{6} V_3 &= 5 \\ V_2 \left[\frac{1}{6} + \frac{1}{4} + \frac{1}{5} \right] - \frac{1}{6} V_1 - \frac{1}{5} V_3 &= -3 \\ V_3 \left[\frac{1}{6} + \frac{1}{5} + \frac{1}{7} \right] - \frac{1}{5} V_2 - \frac{1}{6} V_1 &= 0 \end{aligned}$$

b. $V_1 = 7.238 \text{ V}$, $V_2 = -2.453 \text{ V}$, $V_3 = 1.405 \text{ V}$

c. $R_1 \overset{\uparrow}{\underset{\downarrow}{\text{---}}} \bar{V}_{R_1} = 15 \text{ V} - 7.238 \text{ V} = 7.762 \text{ V}$
 $V_{R_2} = V_2 = -2.453 \text{ V}$, $V_{R_3} = V_3 = 1.405 \text{ V}$
 $V_{R_4} = V_3 - V_2 = 1.405 \text{ V} - (-2.453 \text{ V}) = 3.858 \text{ V}$
 $V_{R_5} = V_1 - V_2 = 7.238 \text{ V} - (-2.453 \text{ V}) = 9.691 \text{ V}$
 $V_{R_6} = V_1 - V_3 = 7.238 \text{ V} - 1.405 \text{ V} = 5.833 \text{ V}$

(II): a. Source conversion: $I = 4 \text{ A}$, $R = 4 \Omega$

$$\begin{aligned} \circ V_1 \quad \circ V_2 \quad \circ V_3 \\ V_1 \left[\frac{1}{9} + \frac{1}{20} + \frac{1}{20} \right] - \frac{1}{20} V_2 - \frac{1}{20} V_3 &= -2 \\ V_2 \left[\frac{1}{20} + \frac{1}{20} + \frac{1}{18} \right] - \frac{1}{20} V_1 - \frac{1}{20} V_3 &= 0 \\ V_3 \left[\frac{1}{20} + \frac{1}{20} + \frac{1}{4} \right] - \frac{1}{20} V_2 - \frac{1}{20} V_1 &= 4 \end{aligned}$$

b. $V_1 = -6.642 \text{ V}$, $V_2 = 1.293 \text{ V}$, $V_3 = 10.664 \text{ V}$

c. $V_{R_1} = V_1 = -6.737 \text{ V}$, $R_2 \overset{\uparrow}{\underset{\downarrow}{\text{---}}} \bar{V}_{R_2} = 16 \text{ V} - 10.676 \text{ V} = 5.324 \text{ V}$
 $V_{R_3} = V_2 = 1.288 \text{ V}$, $V_{R_4} = V_2 - V_1 = 1.288 \text{ V} - (-6.737 \text{ V}) = 8.025 \text{ V}$
 $V_{R_5} = V_3 - V_2 = 10.676 \text{ V} - 1.288 \text{ V} = 9.388 \text{ V}$
 $V_{R_6} = V_3 - V_1 = 10.676 \text{ V} - (-6.737 \text{ V}) = 17.413 \text{ V}$

42. a. $\begin{matrix} I_1 \searrow \\ I_2 \searrow \\ I_3 \searrow \end{matrix} \quad \begin{aligned} I_1(6 + 5 + 10) - 5I_2 - 10I_3 &= 6 \\ I_2(5 + 5 + 5) - 5I_1 - 5I_3 &= 0 \\ I_3(5 + 10 + 20) - 10I_1 - 5I_2 &= 0 \end{aligned}$

$I_1 = 0.3934 \text{ A}$, $I_2 = 0.1770 \text{ A}$, $I_3 = 0.1377 \text{ A}$

b. $I_5 = I_2 - I_3 = 39.34 \text{ mA}$ (direction of I_2)

c, d. no

44. a. $\begin{matrix} I_1 \searrow \\ I_2 \searrow \\ I_3 \searrow \end{matrix} \quad \begin{aligned} I_1(2 \text{ k}\Omega + 33 \text{ k}\Omega + 3.3 \text{ k}\Omega) - 33 \text{ k}\Omega I_2 - 3.3 \text{ k}\Omega I_3 &= 24 \\ I_2(33 \text{ k}\Omega + 56 \text{ k}\Omega + 36 \text{ k}\Omega) - 33 \text{ k}\Omega I_1 - 36 \text{ k}\Omega I_3 &= 0 \\ I_3(3.3 \text{ k}\Omega + 36 \text{ k}\Omega + 5.6 \text{ k}\Omega) - 36 \text{ k}\Omega I_2 - 3.3 \text{ k}\Omega I_1 &= 0 \end{aligned}$

$I_1 = 0.9662 \text{ mA}$, $I_2 = I_3 = 0.3583 \text{ mA}$

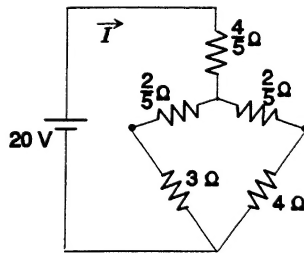
b. $I_5 = I_2 - I_3 = 0.3583 \text{ mA} - 0.3583 \text{ mA} = 0$

c, d. yes

46. Source conversion: $I = 9 \text{ mA}$, $R = 1 \text{ k}\Omega$

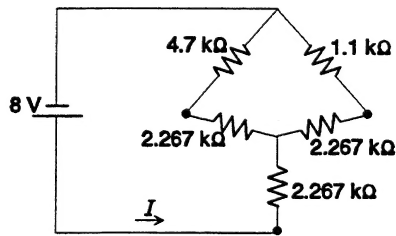
$$\begin{array}{l} \circ V_1 \\ \circ V_2 \quad \circ V_3 \\ \text{---} \end{array} \quad \begin{array}{l} V_1 \left[\frac{1}{1 \text{ k}\Omega} + \frac{1}{100 \text{ k}\Omega} + \frac{1}{200 \text{ k}\Omega} \right] - \frac{1}{100 \text{ k}\Omega} V_2 - \frac{1}{200 \text{ k}\Omega} V_3 = 4 \text{ mA} \\ V_2 \left[\frac{1}{100 \text{ k}\Omega} + \frac{1}{200 \text{ k}\Omega} + \frac{1}{1 \text{ k}\Omega} \right] - \frac{1}{100 \text{ k}\Omega} V_1 - \frac{1}{1 \text{ k}\Omega} V_3 = -9 \text{ mA} \\ V_3 \left[\frac{1}{200 \text{ k}\Omega} + \frac{1}{100 \text{ k}\Omega} + \frac{1}{1 \text{ k}\Omega} \right] - \frac{1}{200 \text{ k}\Omega} V_1 - \frac{1}{1 \text{ k}\Omega} V_2 = 9 \text{ mA} \end{array}$$

48. a.



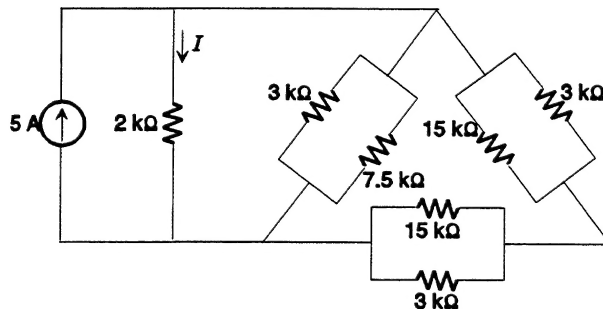
$$\begin{aligned} I &= \frac{20 \text{ V}}{\frac{4}{5} \Omega + \left[\frac{2}{5} \Omega + 3 \Omega \right] \parallel \left[\frac{2}{5} \Omega + 4 \Omega \right]} \\ &= \frac{20 \text{ V}}{\frac{4}{5} \Omega + (3.14 \Omega) \parallel (4.4 \Omega)} \\ &= 7.358 \text{ A} \end{aligned}$$

b.



$$\begin{aligned} R_T &= 2.267 \text{ k}\Omega + [4.7 \text{ k}\Omega + 2.267 \text{ k}\Omega] \parallel [1.1 \text{ k}\Omega + 2.267 \text{ k}\Omega] \\ &= 2.267 \text{ k}\Omega + [6.967 \text{ k}\Omega] \parallel [3.367 \text{ k}\Omega] \\ &= 2.267 \text{ k}\Omega + 2.27 \text{ k}\Omega \\ &= 4.537 \text{ k}\Omega \\ I &= \frac{8 \text{ V}}{4.537 \text{ k}\Omega} = 1.763 \text{ mA} \end{aligned}$$

50.

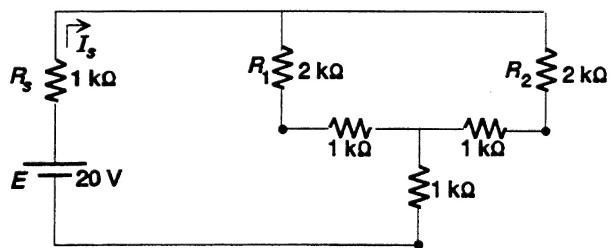


$$\begin{aligned} 3 \text{ k}\Omega \parallel 7.5 \text{ k}\Omega &= 2.14 \text{ k}\Omega \\ 3 \text{ k}\Omega \parallel 15 \text{ k}\Omega &= 2.5 \text{ k}\Omega \end{aligned}$$

$$\begin{aligned} R'_T &= 2.14 \text{ k}\Omega \parallel (2.5 \text{ k}\Omega + 2.5 \text{ k}\Omega) = 1.499 \text{ k}\Omega \\ \text{CDR: } I &= \frac{(1.499 \text{ k}\Omega)(5 \text{ A})}{1.499 \text{ k}\Omega + 2 \text{ k}\Omega} = 2.143 \text{ A} \end{aligned}$$

(Even)

52.



$$R_T = 1 \text{ k}\Omega + 1.5 \text{ k}\Omega + 1 \text{ k}\Omega = 3.5 \text{ k}\Omega$$

$$I_s = \frac{E}{R_T} = \frac{20 \text{ V}}{3.5 \text{ k}\Omega} = 5.714 \text{ mA}$$

$$R' = R_1 + 1 \text{ k}\Omega = 3 \text{ k}\Omega$$

$$R'' = R_2 + 1 \text{ k}\Omega = 3 \text{ k}\Omega$$

$$R'_T = \frac{3 \text{ k}\Omega}{2} = 1.5 \text{ k}\Omega$$